ORIGINAL RESEARCH

# Healthcare Utilization in Patients with Chronic Obstructive Pulmonary Disease Discharged from Coronavirus 2019 Hospitalization

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Video abstract

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**Rationale:** There is concern that patients with chronic obstructive pulmonary disease (COPD) are at greater risk of increased healthcare utilization (HCU) following Severe Acute Respiratory Syndrome-Coronavirus-2 (SARS-COV-2) infection.

**Objective:** To assess whether COPD is an independent risk factor for increased post-discharge HCU.

**Methods:** We conducted a retrospective cohort study of patients with COPD discharged home from a hospitalization due to Coronavirus Disease 2019 (COVID-19) between April 1, 2020, and March 31, 2021, using Optum's de-identified Clinformatics® Data Mart Database (CDM). COVID-19 was identified by an International Classification of Diseases, tenth revision, clinical modification (ICD-10-CM) diagnosis code of U07.1. The primary outcome was HCU (ie, emergency department (ED) visits, readmissions, rehabilitation/skilled nursing facility (SNF) visits, outpatient office visits, and telemedicine visits) nine months post-discharge after COVID-19 hospitalization (from here on "post-discharge") in patients with COPD compared to HCU of patients without COPD. Poisson regression modeling was used to calculate relative risk (RR) and confidence interval (CI) for COPD, adjusted for the other covariates.

**Results:** We identified a cohort of 160,913 patients hospitalized with COVID-19, with 57,756 discharged home and 14,622 (25.3%) diagnosed with COPD. Patients with COPD had a mean age of 75.48 years (±9.49); 55.5% were female and 70.9% were White. Patients with COPD had an increased risk of HCU in the nine months post-discharge after adjusting for the other covariates. Risk of ED visits, readmissions, length of stay during readmission, rehabilitation/SNF visits, outpatient office visits, and telemedicine visits were increased by 57% (RR 1.57; 95% CI 1.53–1.60), 50% (RR 1.50; 95% CI 1.46–1.54), 55% (RR 1.55; 95% CI 1.53–1.56), 18% (RR 1.18; 95% CI 1.14–1.22), 16% (RR 1.16; 95% CI 1.16–1.17), and 28% (RR 1.28; 95% CI 1.24–1.31), respectively. Younger patients (ages 18 to 65 years), women, and Hispanic patients with COPD showed an increased risk for post-discharge HCU.

**Conclusion:** Patients with COPD hospitalized with COVID-19 experienced increased HCU post-discharge compared to patients without COPD.

**Keywords:** COPD, Healthcare Utilization disease, COVID-19

## Introduction

The medical literature has contradicting reports on the outcomes of patients with chronic obstructive pulmonary disease (COPD) infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). At the beginning of the COVID-19 pandemic, patients with COPD were observed to have low rates of hospitalization due to COVID-19. As the pandemic evolved, some studies indicated an association of worse outcomes (eg, higher rates of admission to ICU, use of non-invasive and invasive positive pressure ventilation, and worse mortality) in patients with COPD hospitalized with

COVID-19,[1–4] but other studies did not show this association.[5–8] Many of these studies evaluated hospitalization and ICU use rates and/or mortality as surrogates for healthcare utilization (HCU).[1,9] The post-discharge HCU of patients with COPD hospitalized due to COVID-19, however, has not been well studied.

Prior to the COVID-19 pandemic, patients with COPD were reported to have higher rates of HCU compared to patients without COPD.[10–13] Patients with COPD are more likely to receive care in the emergency department (ED) or be hospitalized at least once per year, and they tend to have longer average length of stay and higher cost of inpatient care.[14] Patients with COPD also have a higher risk of post-discharge readmissions, and those readmitted are at increased risk of death.[15,16] COPD is a leading reason for office-based visits.[10,14,17] Moreover, HCU of patients with COPD is greater in current smokers with advanced age, greater number of comorbidities, and worse airflow obstruction.[10–14,18–21]

The aim of this study was to evaluate whether COPD is an independent risk factor for increased post-discharge HCU after COVID-19 hospitalization. A better understanding of the risk of post-discharge HCU in patients with COPD and COVID-19 could help prioritize and implement healthcare policies for this population, such as aggressive preventive measures (eg, non-pharmacologic interventions to mitigate the risk of infection) and proactive COVID-19 vaccination. Some of the content of this work has been previously presented in the form of a conference abstract.[22]

## Methods

### Data Source

In this retrospective cohort study, we used Optum's Clinformatics® Data Mart Database (CDM), a statistically de-identified and HIPAA-compliant database of administrative health claims for over 67 million people from all 50 states in the United States. CDM contains claims data from individuals with commercial and Medicare Advantage insurance plans. The University of Texas Medical Branch Institutional Review Board approved this study (IRB# is 20–0180). Written informed consent was not required due to the de-identified nature of the patient data.
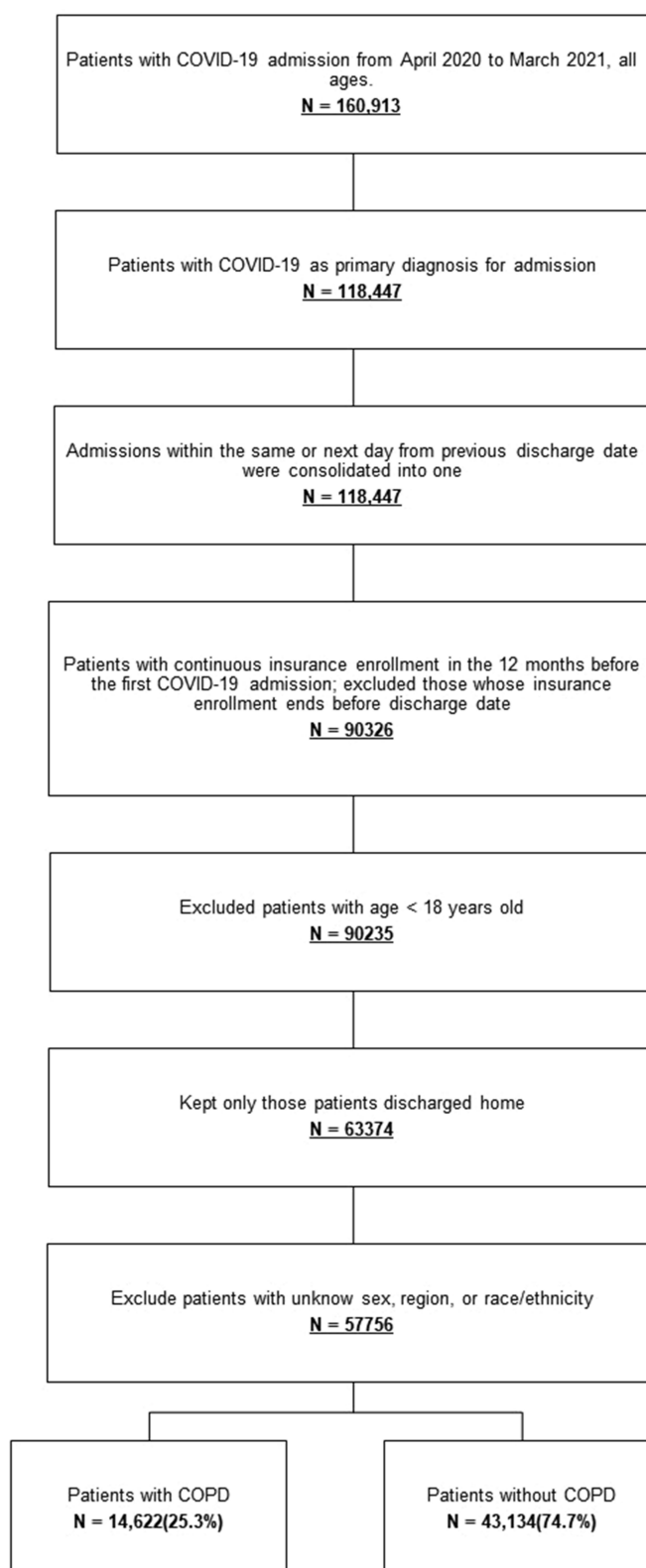
### Cohort

The study cohort consisted of patients hospitalized with a primary diagnosis of COVID-19 between April 1, 2020, and March 31, 2021, as identified by an ICD-10-CM diagnosis code of U07.1. We excluded patients <18 years old; patients not discharged to home; patients with incomplete information on gender, region, or race/ethnicity; and patients with continuous enrollment <12 months before hospitalization or whose enrollment ended before the discharge date (Figure 1).

### Variables

The index date was defined as the date of discharge from hospitalization due to COVID-19. The primary outcome was HCU nine months after the index date in patients with COPD. Subsequently, HCU was compared to patients without COPD during the same period. HCU included ED visits, readmissions, and length of stay during readmissions, rehabilitation/skilled nursing facility (SNF) visits, outpatient office visits, and telemedicine visits. The main independent variable of interest was COPD, which was defined as having experienced one inpatient or two outpatient visits for COPD in the year prior to the index date (Table S1). Other independent variables included age, gender, race/ethnicity, region, COVID-19 hospitalization length of stay, and number of comorbidities. HCU was measured in person-days, which was calculated as the number of days between the index date and the end of the study, death, or the end of enrollment, whichever came first.

### Statistical Analysis

Patient and clinical characteristics were summarized by COPD status as frequencies, percentages, or mean ±standard deviation (SD). Comparison between COPD and non-COPD groups was performed using chi-square statistics or $t$-tests as appropriate. The HCU of patients with COPD after COVID-19 hospitalization was measured in 10,000 (10k) person-days and compared with patients without COPD. A Poisson regression was used to determine if COPD was an independent risk factor for HCU after adjustment for other variables. The outcomes were the number of post-discharge ED visits, readmissions, and length of stay during readmission, rehabilitation/SNF visits, outpatient office visits, and telemedicine visits in the nine months after the index date. Person-days were included in the Poisson model as an offset to account for the different subject follow-up times. The interactions

**Figure 1** Flow diagram of our cohort selection process. Our cohort was obtained from Optum's de-identified Clinformatics® Data Mart Database (CDM). It consists of 57,756 patients who were discharged home from a hospitalization due to COVID-19 from April 2020 until March 2021. From this, 14,622(25.3%) were identified as having COPD. COPD was defined as having at least one inpatient or two outpatient diagnoses in the one year prior to COVID-19 diagnosis (see Table S1).

between COPD and age, gender, and race/ethnicity were examined in the Poisson model. The Poisson model was stratified by age, gender, or race/ethnicity to show the impact of COPD on HCU in each subgroup if the interaction term was found to be significant at the 5% nominal level. As a sensitivity analysis, to evaluate the influence of individual comorbidities in the relative risk of HCU in patients with COPD, the multivariable model was built including each of the comorbidities independently rather than grouping them in a composite measure (Comorbidities ≥3) (Tables S2–S5). Baseline HCU of patients with COPD in 2019 is shown in Table S6. All analyses were performed with SAS 9.4 (SAS, Inc., Cary, North Carolina). P-value <0.05 was considered significant.

## Results

We had a cohort of 160,913 patients admitted with the principal diagnosis of COVID-19, of which 57,756 patients were discharged home. Of these patients, 25.3% (14,622) had a diagnosis of COPD. Patients with COPD had a mean age of 75.48 ± 9.49, 55.5% were female, and 70.9% were White. Most patients with COPD (91.8%) had three or more comorbidities, and 35% of these patients received care in the intensive care unit (Table 1).

**Table 1** Characteristics of Patients with and without COPD Discharged Home from Hospitalization Due to COVID-19 in the United States from April 2020 Until March 2021[a]

| Characteristics | Levels | COPD,[b] n (%)[c] | No COPD, n (%)[c] | P-value |
|---|---|---|---|---|
| – | | 14,622 (25.3) | 43,134 (74.7) | – |
| Age | 18–64 | 1771 (12.1) | 10,636 (24.7) | <0.0001 |
| – | ≥65 | 12,851 (87.9) | 32,498 (75.3) | – |
| Age, mean (±SD) | – | 75.48 (±9.49) | 71.58 (±13.43) | <0.0001 |
| Gender | Female | 8111 (55.5) | 23,155 (53.7) | 0.0002 |
| – | Male | 6511 (44.5) | 19,979 (46.3) | – |
| Race/ethnicity[d,e] | Black | 2671 (18.3) | 7798 (18.1) | <0.0001 |
| – | Hispanic | 1590 (10.9) | 8392 (19.5) | – |
| – | White | 10,361 (70.9) | 26,944 (62.5) | – |
| Region | Midwest | 3512 (24) | 9744 (22.6) | <0.0001 |
| – | Northeast | 1997 (13.7) | 5815 (13.5) | – |
| – | South | 7221 (49.4) | 21,225 (49.2) | – |
| – | West | 1892 (12.9) | 6350 (14.7) | – |
| Diabetes mellitus | – | 7299 (49.9) | 19,347 (44.9) | <0.0001 |
| Hypertension | – | 13,630 (93.2) | 36,575 (84.8) | <0.0001 |
| Asthma | – | 3856 (26.4) | 4878 (11.3) | <0.0001 |
| Chronic kidney disease | – | 3707 (25.4) | 6836 (15.8) | <0.0001 |
| End-stage renal disease | – | 670 (4.6) | 1321 (3.1) | <0.0001 |
| Stroke | – | 2423 (16.6) | 5097 (11.8) | <0.0001 |
| Congestive heart failure | – | 7368 (50.4) | 10,599 (24.6) | <0.0001 |
| Cancer | – | 3458 (23.6) | 7350 (17) | <0.0001 |
| Coronary artery disease | – | 7381 (50.5) | 12,013 (27.9) | <0.0001 |
| Liver disease | – | 2030 (13.9) | 4583 (10.6) | <0.0001 |
| Elixhauser comorbidity index | 0 | 169 (1.2) | 3410 (7.9) | <0.0001 |
| – | 1 | 332 (2.3) | 3914 (9.1) | – |
| – | 2 | 698 (4.8) | 5109 (11.8) | – |
| – | ≥3 | 13,423 (91.8) | 30,701 (71.2) | – |
| Intensive care unit | Yes | 5114 (35) | 14,719 (34.1) | 0.0612 |
| Length of stay in COVID-19 hospitalization, mean (±SD) | – | 12.87 (15.74) | 11.39 (15.66) | <0.0001 |

**Notes**: [a]Our cohort was obtained from Optum's de-identified Clinformatics® Data Mart Database (CDM), which includes medical claim data for more than 67 million patients across multiple hospital networks from all regions in the United States. The study cohort consists of patients who were discharged home from a hospitalization due to COVID-19 as the primary diagnosis, as identified by an ICD-10-CM diagnosis code of U07.1. Patients needed to have 12-month continuous enrollment before COVID-19 diagnosis. [b]Presence of COPD was defined as having at least one inpatient or two outpatient diagnoses in the one year prior to COVID-19 diagnosis (Table S1). [c]Percentages calculated from cohort of patients discharged home from hospitalization due to COVID-19. [d]Patients self-identifying as non-Hispanic ethnicity were categorized based on race (White, Black, other/unknown). [e]Patients self-identifying as Hispanic ethnicity were included in the Hispanic group regardless of race.
**Abbreviations**: COVID-19, Coronavirus Disease 2019; EHR, Electronic Health Record; COPD, Chronic Obstructive Pulmonary Disease; SD, Standard Deviation; ICD-10-CM, International Classification of Diseases, tenth revision, clinical modification.

In the nine months post-discharge, patients with COPD had significantly higher HCU than patients without COPD. Post-discharge ED visits, readmissions, length of stay during readmission, rehabilitation/SNF visits, outpatient office visits, and telemedicine visits relatively increased by 78.7%, 57.9%, 69.4%, 46.5%, 22.5%, and 38.2%, respectively (Table 2). Results from the multivariable Poisson regression model showed that patients with COPD are at increased risk for HCU in the nine months post-discharge. The risk of ED visits, readmissions, length of stay during readmissions, rehabilitation/SNF visits, outpatient office visits, and telemedicine visits were increased by 57% (RR 1.57; 95% CI 1.53–1.60), 50% (RR 1.50; 95% CI 1.46–1.54), 55% (RR 1.55; 95% CI 1.53–1.56), 18% (RR 1.18; 95% CI 1.14–1.22), 16% (RR 1.16; 95% CI 1.16–1.17), and 28% (RR 1.28; 95% CI 1.24–1.31), respectively (Table 3).

**Table 2** Healthcare Utilization[a] Comparison in Patients[b] with and without COPD[c] Within Nine Months Post-Discharge Home from COVID-19 Hospitalization

|  | Patients with COPD Visits per 10k Person-Days | Patients without COPD Visits per 10k Person-Days | Percentage Change[d] |
|---|---|---|---|
| ED | 46.3 | 25.9 | 78.7 |
| Readmissions | 25 | 15.8 | 57.9 |
| Readmissions LOS[e] | 180.6 | 106.6 | 69.4 |
| Rehabilitation/SNF | 16.8 | 11.5 | 46.5 |
| Outpatient office | 292.5 | 238.7 | 22.5 |
| Telemedicine | 21.3 | 15.4 | 38.2 |

**Notes**: [a]HCU is defined as visits to ED, readmissions (and readmissions LOS), rehabilitation/SNF, outpatient office, and telemedicine visits and counted per 10K person-days. [b]Our cohort was obtained from Optum's de-identified Clinformatics® Data Mart Database (CDM). It consists of 57,756 patients who were discharged home from a hospitalization due to COVID-19 from April 2020 until March 2021. From this, 14,622 (25.3%) were identified as having COPD. [c]COPD was defined as having at least one inpatient or two outpatient diagnoses in the one year prior to COVID-19 diagnosis (Table S1). [d]Percentage change compares overall change in HCU in patients with COPD to patients without COPD post-discharge home from COVID-19 hospitalization. [e]Length of stay during readmissions is measured as inpatient days during readmission hospitalization per 10K persons-days.
**Abbreviations**: COVID-19, Coronavirus Disease 2019; COPD, Chronic Obstructive Pulmonary Disease; HCU, Healthcare Utilization; ED, Emergency Department; 10K, 10,000; LOS, Length of stay; SNF, Skilled nursing facility.

**Table 3** Multivariable Model of the Risk of HCU[a,b] in Patients with COPD[c,d] Post-Discharge Home from COVID-19 Hospitalization

| Healthcare Utilization | Relative Risk (95% CI) |
|---|---|
| ED visits | 1.53 (1.50–1.56) |
| Readmissions | 1.45 (1.41–1.49) |
| Readmission LOS | 1.50 (1.49–1.52) |
| Rehab visits | 1.16 (1.12–1.20) |
| Office visits | 1.15 (1.14–1.16) |
| Telemedicine visits | 1.26 (1.22–1.30) |
| Pulmonary rehab | 0.97 (0.96–0.98) |

**Notes**: [a]Risk of HCU in patients with COPD and adjusted on all covariates. [b]Multivariable Poisson regression model for all patients: log (HCU) = intercept+ Age + LOS + Gender + Race + Region + ICU + # comorbidities + COPD + log (Person days), where LOS is the length of stay in the index COVID-19 hospitalization. [c]Our cohort was obtained from Optum's de-identified Clinformatics® Data Mart Database (CDM). It consists of 57,756 patients who were discharged home from a hospitalization due to COVID-19 from April 2020 until March 2021. From this, 14,622 (25.3%) were identified as having COPD. [d]COPD was defined as having at least one inpatient or two outpatient diagnoses in the one year prior to COVID-19 diagnosis (see Table S1).
**Abbreviations**: COVID-19, Coronavirus Disease 2019; COPD, Chronic Obstructive Pulmonary Disease; HCU, Healthcare Utilization; log, logarithm; ED, Emergency Department.

We analyzed interactions between COPD and age, COPD and gender, and COPD and race/ethnicity in HCU outcomes. We conducted a stratified Poisson regression model, stratifying by age, gender, and race/ethnicity, when the corresponding interaction term was significant. We also included in the model each of the comorbidities independently rather than grouping them into a composite measure (Comorbidities ≥3) (Tables S3–S5). Both younger (age 18–64 years) and older (age ≥65 years) patients with COPD showed an increased relative risk of all measures of HCU post-COVID-19 hospitalization. Interestingly though, younger patients with COPD had 62% increased risk of ED visits (RR 1.62; 95% CI 1.54–1.70), 28% increased risk of readmissions (RR 1.28; 95% CI 1.19-1.36), and 50% greater risk of a longer length of stay during readmissions (RR 1.50; 95% CI 1.44–1.52) compared to patients without COPD. Also, this younger group showed 37% higher risk for telemedicine visits (RR1.37; 95% CI 1.30–1.50) and 13% increased risk for office visits (RR 1.13; 95% CI 1.11–1.20) (Table S3).

Although both men and women with COPD had an increased risk of HCU post-COVID compared to patients without COPD, the analysis of interactions between COPD and sex in HCU outcomes revealed that women with COPD had 40% increased risk for readmissions (RR 1.40; 95% CI 1.30–1.41) and 42% risk for longer length of stay during readmission (RR 1.42; 95% CI 1.40–1.44). Men's risk of readmissions and longer length of stay during readmission was 30% (RR 1.30; 95% CI 1.22–1.32) and 28% (RR 1.40; 95% CI 1.30–1.41) (Table S4).

Similarly, HCU was worse in patients with COPD post-COVID-19 discharge across all examined races/ethnic backgrounds. The analysis of the interaction between COPD and race/ethnicity in HCU showed that Hispanic patients with COPD have a higher risk of HCU across the board (Table S5).

## Discussion

In this retrospective study of patients with COPD who were discharged home after COVID-related hospitalization, patients with COPD had greater HCU than patients without COPD over a 9-month period. HCU was measured as a composite of ED visits, readmissions, length of stay during readmissions, admission to rehabilitation or skilled nursing facilities, outpatient office visits, and telemedicine visits. Moreover, as shown previously, the diagnosis of COPD was independently associated with greater HCU. Our main findings were the association between higher HCU and a diagnosis of COPD in patients younger than 65 years old, women, and patients with Hispanic ethnicity. The findings of greater healthcare utilization following a COVID-related hospitalization are similar to that observed in studies demonstrating an association between healthcare utilization following hospitalization for an acute exacerbation of COPD (AECOPD).[12,15,23]

AECOPD is usually caused by viral and/or bacterial infections, and patients with COPD discharged home after hospitalization for COPD exacerbation are at increased risk of mortality, readmissions, and greater HCU.[10–13] These outcomes are mediated by age[13] and comorbidities[24–26] and are reported in the older population with COPD. Similarly, our findings indicate that patients with COPD have a greater risk of ED visits and readmissions. Importantly, our findings demonstrating 62% increased risk of ED visits and 28% increased risk of readmissions in younger patients with COPD (<65 years old) deserve careful attention. This finding has major implications for health resource planning considering that ~30% of the associated health burden may be due to COVID-19 related disability and HCU.[27–30]

Our second main finding corresponds to the high risk of HCU in women with COPD post-discharge from COVID-19. In general, women appeared to be protected from the adverse effects of SARS-COV-2 infection, showing better outcomes than male patients.[31,32] However, women with COPD who are hospitalized with COVID-19 may have an increased risk of mortality,[1] and, based on our findings, those who survive may be at risk of high HCU post-discharge (ie, 36% increased risk for ED visits, 40% increased risk for readmissions, and 42% risk for longer length of stay during readmission, etc.) (Table S4). The differences in HCU in women with COPD post COVID-19 infection may be explained by social rather than biological variables.[33]

Our third main finding was the racial/ethnic differences in the HCU of patients with COPD post-COVID-19 hospitalization (Table S5). There are known disparities in care, such as higher odds of being undiagnosed, greater barriers to access care and possibly worse outcomes for Black and Hispanic patients with COPD.[34–40] In our study we found that Black and Hispanic patients with COPD discharged home after a COVID-19 hospitalization have an increased

risk for HCU compared to patients without COPD (Table S5). But Hispanic patients' 40% increased risk of ED visits and readmissions should be noticed. This is because, historically, Hispanic patients have had lower odds of readmission and mortality due to COPD, raising the concept of the "Hispanic paradox".[41–43] The observed higher HCU in our study could be explained by higher clinical risk profiles, for example, more comorbidities, more prior acute stays, more ICU admissions, and longer lengths of stay,[43] but variations in smoking patterns, environmental exposures, genetic suscept-ibility, and healthcare access may also play a role.[44]

We are uncertain as to whether the observed increase in HCU in patients with COPD reflects increased susceptibility to post-acute sequelae of SARS-CoV-2 infection (also known as post-acute COVID-19 syndrome) or other factors.[45] With an increasing number of COVID-19 survivors,[9] post-acute COVID-19 syndrome has emerged as a disorder of ongoing healthcare use.[46,47] This syndrome is described in patients who continue to have signs and symptoms of the illness four weeks after the initial diagnosis of the SARS-CoV-2 infection, which are not explained by other causes.[45,48] Symptoms can vary, including chronic cough, persistent or worsening shortness of breath, palpitations, neuropathy, cognitive impairment, fatigue, and anxiety.[48] Observational studies have shown that the prevalence of post-acute sequelae of SARS-CoV-2 infection is between 10% and 30% in the general population, with symptoms lasting for several months.[30,48] This syndrome is more common in older individuals, patients with pre-existing conditions, and patients who have required hospital admission for acute SARS-CoV-2 infection.[49]

Our study has several strengths, including a large sample size and a nine-month post-discharge follow-up after COVID-19 hospitalization. Limitations include the retrospective design that can only evaluate associations and does not infer causality. Thus, the increased risk in HCU observed in patients with COPD could be related to other unmeasured confounding variables.[13,24–26] Additionally, increased HCU is linked to the degree of airflow obstruction in patients with COPD[25,26] and our administrative database did not provide spirometry data, thus we were unable to determine the degree of airflow obstruction. Yet, investigators have examined HCU of patients with COPD using administrative claims data and assessed disease severity in the absence of spirometry measurements.[50–52] Similarly, HCU in COPD is linked to increased age and number of comorbidities, and we found an increased risk of HCU in the older population (age 65 years and older) with more comorbid conditions. Notably, the finding of high HCU (after adjusting for comorbidities) in the younger population with COPD, who may have less comorbidities, is intriguing and may be examined in future investigations. The potential interactions between COPD, comorbid conditions, and increased HCU remain relevant.[26]

## Conclusion
Patients with COPD hospitalized with COVID-19 experienced increased HCU post-discharge.

## Abbreviations
CAD, Coronary Artery Disease; CHF, Congestive Heart Failure; CKD, Chronic Kidney Disease; COPD, Chronic Obstructive Pulmonary Disease; COVID-19, Coronavirus Disease 2019; DM, Diabetes Mellitus; ED, Emergency Department; ESRD, End-Stage Renal Disease; HCU, healthcare utilization; HTN, Hypertension; ICD-10-CM, International Classification for Diseases, tenth revision, clinical modification; ICU, Intensive Care Unit; LOS, length of stay; PCP, Primary Care Provider, SNF, skilled nursing facility, SD, Standard Deviation.

## Author Contributions
All authors made a significant contribution to the work reported in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; agreed on the journal to which the article has been submitted; and agreed to be accountable for all aspects of the work.

## Disclosure

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